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Powdery mildew (*Blumeria graminis f.* sp. *tritici*) infection and amount of key defence chemicals - cyclic hydroxamic acids - of field cultivated wheat (*Triticum aestivum* L.)

Lisztharmat (*Blumeria graminis f.* sp. *tritici*) fertőzöttség és a növényi védekezésben központi szerepet betöltő ciklikus hidroxámsavak mennyisége őszi búzában (*Triticum aestivum* L.)

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ABSTRACT

Cultivated wheat varieties have different degrees of resistance against powdery mildew. Cyclic hydroxamic acids are key defence chemicals of wheat. Examinations comprised the measurement of cyclic hydroxamic acid content and powdery mildew infection of three varieties (Lukullus, Lennox, Ispán) and a hybrid (Hystar) of field cultivated wheat, and the effectivity of two biological (Polyversum and Trifender) and one conventional fungicide (Sólyom) on powdery mildew. Sample collection and measurement of fungus infection were carried out on three occasions: at BBCH 23-24, BBCH 32-33 and BBCH 77-83 phenological phases. Variety/hybrid and sampling time has significant effect on cyclic hydroxamic acid content, but there was no direct correlation between hydroxamic acid content and powdery mildew infection. Differences were found amongst varieties/hybrid in powdery mildew infection too. Only the hybrid, Hystar, showed considerable infection at every sampling time. The conventional chemical out of fungicides alone proved to be effective, and its effectivity lasted for five weeks.

Keywords: biotic stress, conventional and biological fungicides, defence chemicals

ÖSSZEFOGLALÁS

A termesztett őszi búza fajtáknak/hibrideknek eltérő lisztharmat fogékonysága van. A ciklikus hidroxámsavak az őszi búza károsítókkal szembeni védelmében központi szerepe töltenek be. Három őszi búza fajta (Lukullus, Lennox, Ispán) és egy hybrid (Hystar) ciklikus hidroxámsav-tartalmát és lisztharmat fertőzöttségét, valamint két biológiai (Polyversum and Trifender) és egy hagyományos gombaölő szer (Sólyom) lisztharmattal szembeni hatékonyságát vizsgáltuk szántóföldi körülmények között. A mintavételek és a lisztharmat fertőzöttség felmérése három fenológiai fázisban történt (BBCH 23-24; BBCH 32-33 és BBCH 77-83). A fajta/hybrid és a mintavétel időpontja szignifikánsan befolyásolta a ciklikus hidroxámsav-tartalmat, a lisztharmat fertőzöttség és a ciklikus hidroxámsav-tartalom között azonban nem volt megállapítható összefüggés. A fajták/hybrid között a lisztharmat fertőzöttség tekintetében szintén szignifikáns különbségeket figyeltünk meg. Kizárólag a Hystar hybrid mutatott mindhárom mintavételi időpontban számottevő fertőzöttséget. A gombaölő szerek közül csak a hagyományos, kémiai (Sólyom) bizonyult hatékonynak, öt hét tartamhatással.

Kulcsszavak: biotikus stress, hagyományos és biológiai gombaölő szerek, vegyületek az önvédelemben

INTRODUCTION

The sowing area of wheat (*Tricum aestivum* L.) in Hungary in 2018 was almost 1 million hectares (Central Bureau of Statistics, Hungary). Powdery mildew infects wheat regularly, on 60-90% of the cultivated area, resulting in a loss of crop of 5-25% (Horváth, 1995). Cyclic hydroxamic acids are self-protecting chemicals of most *Poaceae* family plants, like wheat, maize and rye (Niemeyer, 1988; 2009). The correlation between their quantity and plant disease susceptibility has been proved in several cases (Niemeyer, 1988; Nakagawa et al., 1995; Zheng et al., 2005). There are scarce data in connection with the effects of cyclic hydroxamic acids on powdery mildew susceptibility (Brandes and Heitefuss, 1971; Zheng et al., 2005). The purpose of the examinations were the determination of cyclic hydroxamic acid content in different phenological phases and the evaluation of powdery mildew infection of various field cultivated wheat varieties. The examinations covered the evaluation of biological and conventional fungicides' effectiveness on powdery mildew and the effect of their application on cyclic hydroxamic acid content.

MATERIALS AND METHODS

Settling of the experiment, agricultural techniques

The experiment was set up on the fields of „Kurucz Farm Kft.", near the parish of Ebes, which is located in the north-east of Hungary. The area of the experimental field was 11.22 hectares. Its soil is chernozem, with considerable lime content with a flat and smooth surface. After the harvesting of sunflower, the preceding crop, 20 tons/hectare organic manure was used for basic nutrition. After manure application, disc tiller was used. A cultivator was used to prepare the soil before sowing. Sowing was performed on the 1st of November 2017, with special attention to the moisture content of the soil. Three varieties and one hybrid were sowed (Lukullus, Lennox, Ispán and Hystar) at right angles to the border of the field, in two sowing-machine widths, in 300 m long distance rows. Additional fertilizations were performed in February and in April. 100 and 150 kilograms/hectare of ammonium-nitrate were used on the two respective occasions. In April a micronutrients solution was sprayed (Omex – 2 liters/ha and Epsom salt (7 kilograms / hectare) were applied. On 24th April Gramma Extra (20 grams/hectare) and Mecomorn 750 SL (1 liter/hectare) herbicides were sprayed. At the end of May, King 10EC (0.1 liter/hectare) insectiside was applied against *Oulema melanopus*. The experimental treatments in three repetitions were as follows: Trifender Pro (0.5 kilogram/hectare), Polyversum (1.0 kilogram/hectare) and Sólyom (0.6 liter/hectare). Plots without any treatment served as control. Plots were 12 meters wide. There was no additional fungicide treatment in the experimental field. Treatments were carried out on 11th April. At that time the temperature was 15 degree celsius and the sky was cloudy. Polyversum, a biological fungicide, contains the fungus *Pythium oligandrum*, which parasitizes several pathogen fungi and stimulates the plants' self-defence. Trifender Pro includes the *Trichoderma asperellum* T34 strain, an antibiotics producing fungus-parasite. The specific feature of this experiment is the foliar application of this plant stimulator. Sólyom is a traditional chemical fungicide with tebuconazole, triadimenol and spiroxamine active ingredients.

Sample collection

The first sampling was fulfilled 7 days after experimental treatments, on 18th April, at BBCH 23-24, with the second carried out on 16th May at BBCH 32-33 and the third sampling performed on 14th June at BBCH 77-83 phenological phase. At the first sampling the youngest emerged leaf of the main shoot, at the second sampling the third emerged leaf on the main shoot (the still infected leaf on the highest level of the shoots), and at the third sampling the flag leaf were selected for sampling. At first sampling, 10 samples were collected per treatment, varieties/hybrid and repetitions, which amounts to 480 samples (4 varieties/hybrid x 4 treatments x 3 repetitions x 10 samples). At second and third samplings, 8 samples were collected per treatment, varieties/hybrid and repetitions in each, providing us 384 samples for each sampling. Altogether 1248 samples were cut out and prepared lately. Samples at the time of sampling were temporarily stored in freezer bags. Until processing, samples were stored at minus 80 centigrade in the lab.

Evaluation of powdery mildew infection

The weather in early spring of 2018 was not favourable for fungal diseases. Monitoring of fungal infection was carried out twice in the spring, on 16th March and 5th April. Powdery mildew appearance was noticed on the second occasion. Other fungal diseases did not appear in the growing season. Powdery mildew infection was evaluated by surveying 20, randomly chosen plants from each plot. Evaluation was made on the same day as sample collection. At the first sampling, the ratio of infested plants, at the second sampling the ratio of infected part of the sampled leaves, and at the third sampling the ratio of infected plants and the ratio of infected area on flag leaves were determined. As at the third sampling only Hystar's flag leaves were infected, only Hystar's infection was evaluated.

Sample preparation and the steps of cyclic hydroxamic acids determination

Deposited samples from a deep freezer were prepared according to Lyons et al., (1988). The total amount of cyclic hydroxamic acids was determined using the spectrophotometric method of Long et al., (1974) modified by Makleit et al., (2012). Accordingly, the residues of the evaporated ethyl acetate phases were dissolved in 1.9 mL, equal ratio mixture of 96% ethanol and 0.1n hydrochloric acid. Then 0.1 mL 0.1 n ferric chloride was added to this mixture and the absorbance of complex was measured at 570 nm. The amount of cyclic hydroxamic acid was calculated from standard curves, constructed by using various amounts of isolated cyclic hydroxamic acids (Makleit et al., 2012).

Plant growing in climate chamber

Wheat plants (variety GK Csillag) were cultivated in a climate chamber in soil, under controlled conditions: light/dark regime 10/14 h at 24/20°C, relative humidity of 65–70% and a photosynthetic photon flux of 390 m E/m2/s.

Statistical analysis methods

Statistical analyses were performed by using SPSS version 23.0. For normal distribution of data, t-test or analysis of variance were used. For determination of homogenous subjects Duncan's test was applied. Where data distribution was not normal, nonparametric tests were appropriate. Correlation analyses were carried out by generating and evaluating scatter plots.

RESULTS

Comparison of cyclic hydroxamic acid content of varieties/hybrid

Comparison of all experimental data by varieties/hybrid revealed that Lukullus and Lennox had lower and equal (Lukullus: 180.72±4.39; Lennox: 183.00±4.34 mg/kg fresh weight), Ispán and Hystar had higher and also equal (Ispán: 249.97±5.76; Hystar: 266.44±6.67 mg/kg fresh weight) total cyclic hydroxamic acid content (Figure 1).

With comparison of varieties/hybrid per treatments, the same result was detected as with comparison of all data. Table 1 shows the total cyclic hydroxamic acid contents of varieties/hybrid by treatments.

Total cyclic hydroxamic acid contents of varieties/hybrid was compared by sampling occasions too. Table 2 shows the obtained result.

Similarly to the above comparisons, at first sampling, the total cyclic hydroxamic acid contents of varieties Lukullus and Lennox were lower but equal than those of the variety Ispán and hybrid Hystar, which had higher, but also equal, total cyclic hydroxamic acid contents. At second sampling, total cyclic hydroxamic acid contents of all varieties/hybrid differed from each other. Total cyclic hydroxamic acid contents in increasing order were Lennox → Lukullus → Ispán → Hystar. At third sampling the total cyclic hydroxamic acid contents of variety Ispán

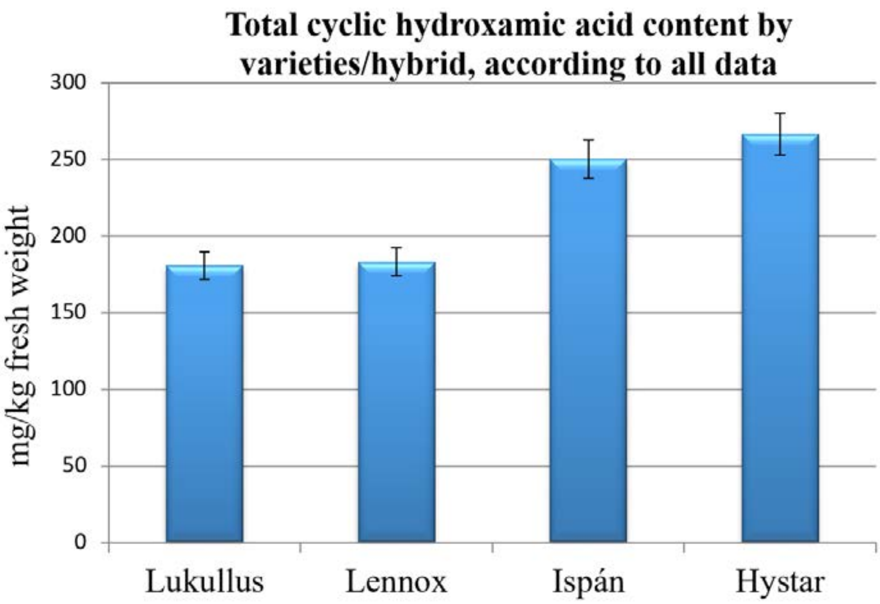

Figure 1. Total cyclic hydroxamic acid content of varieties/hybrid (mg/kg fresh weight; n=312; ±SE)

Table 1. Total cyclic hydroxamic acid content of varieties/hybrid by treatments (mg/kg fresh weight; n=78; ±SE)

	Treatments[1]			
Varieties/Hybrid	Control	Trifender Pro	Polyversum	Sólyom
Lukullus	180.13±8.87[a]	183.46±8.81[a]	175.70±8.30[a]	183.65±9.22[a]
Lennox	180.15±7.51[a]	181.67±8.18[a]	180.40±9.38[a]	189.77±9.55[a]
Ispán	260.68±11.71[b]	251.77±11.04[b]	252.76±12.61[b]	234.30±10.54[b]
Hystar	284.85±14.33[b]	253.40±13.77[b]	260.27±13.55[b]	265.79±12.62[b]

[1] Letters indicate different groups in the same coloumn according to statistical tests

Table 2. Total cyclic hydroxamic acid contents of varieties/hybrid by sampling times (mg/kg fresh weight; n=104; ±SE)

	Varieties/Hybrid[1]			
Sampling	Lukullus	Lennox	Ispán	Hystar
I.	245.05±6.07[a]	256.25±5.29[a]	293.86±6.27[a]	285.46±6.04[b]
II.	172.38±5.97[b]	150.63±5.39[b]	301.66±9.71[a]	371.73±9.51[a]
III.	110.73±2.33[c]	124.26±2.96[c]	143.32±4.70[b]	136.45c±4.99[c]

[1] Letters indicate different groups in the same coloumn according to statistical tests

and hybrid Hystar were equal, but higher, than total cyclic hydroxamic acid contents of varieties Lukullus and Lennox. In this case the variety Lukullus had lower total cyclic hydroxamic acid content than had Lennox.

Effect of treatments on total cyclic hydroxamic acid content

On the average of all varieties/hybrid, there were no differences among treatments (Polyversum: 217.28±5.99; Trifender Pro: 218.04±5.56; Control: 226.07±6.04; Sólyom: 218.12±5.59 mg/kg fresh weight). Table 3 shows the effect of treatments by sampling times, on total cyclic hydroxamic acid content.

The data in Table 3 suggest that there were no differences between treatments at the same, examined sampling times.

Table 3. Effect of treatments by sampling times, on total cyclic hydroxamic acid content (mg/kg fresh weight; n=104; ±SE)

Treatment/ Sampling	I.	II.	III.
Polyversum	266.04±5.94[a]	249.70±13.44[a]	123.91±3.52[a]
Trifender Pro	267.57±5.84[a]	249.60±11.38[a]	127.05±3.75[a]
Control	277.89±6.60[a]	259.56±12.54[a]	128.51±4.05[a]
Sólyom	269.23±6.37[a]	237.53±11.48[a]	135.03±4.89[a]

[1] Letters indicate different groups in the same coloumn according to statistical tests

No effect of treatments could be detected, either, when examined per varieties/hybrid (Table 1). Multifactorial analysis of variance was also performed to evaluate the various factors' effect on total cyclic hydroxamic acid content. This statistical method proved, too, that the experimental treatments, either by themselves or in interaction with other factors, had no effect on total cyclic hydroxamic acid content.

Prior to the experiment in the field, the effect of a treatment on total cyclic hydroxamic acid content was investigated in a laboratory, in a climate chamber. 10 day -old wheat plants (variety GK Csillag) were treated with the 0.3 v/v% Polyversum solution. Control plants were treated with distilled water. Total cyclic hydroxamic acid content was measured from the youngest emerged leaf, 1, 2, 4 and 7 days after treatment. Table 4 shows the measured data.

With respect to data evaluation, treatment using Polyversum had no effect on total cyclic hydroxamic acid content in the examined period of time. It was supposed that investigation of treatments in field conditions, and with other varieties could lead to different results.

Effect of sampling time on total cyclic hydroxamic acid content

Different total cyclic hydroxamic acid contents were measured when the results calculated on the data of all varieties/hybrid, collected at various sampling times were compared. It was 270.21±3.10 mg/kg fresh weight at the first, 249.04±6.11 mg/kg fresh weight at the second and 128.60±2.04 mg/kg fresh weight at the third sampling time. The highest total cyclic hydroxamic acid content was measured at the first, and the lowest at the third sampling time.

Examination of the effect of sampling time per treatments on total cyclic hydroxamic acid content showed that in all treatments and the control led to similar results to those of the investigation of all varieties/hybrid (See Table 3).

Examination of the effect of sampling time total cyclic hydroxamic acid content per varieties/hybrid suggests that Lennox and Lukullus varieties showed the above tendency. Total cyclic hydroxamic acid content of the variety Ispán proved to be equal at the first and second and decreased only at the third sampling time. Changes in the total cyclic hydroxamic acid contents of hybrid Hystar showed a special trend. They were the highest at the second and the lowest at the third sampling time (Table 2). Multifactorial analysis of variance also demonstrated the significant effect of sampling time on the total cyclic hydroxamic acid contents.

Table 4. Effect of Polyversum treatment on total cyclic hydroxamic acid content of wheat grown in climate chamber (mg/kg fresh weight; n=5; ±SE)

Treatment/Sampling	1 day[1,2]	2 days[1,2]	4 days[1,2]	7 days[1,2]
Control[2]	70.05±4.61[a]	91.86±15.95[a]	84.00±14.06[a]	55.18±10.34[a]
Polyversum[2]	89.24±9.79[a]	82.3±15.09[a]	67.57±13.80[a]	62.19±11.52[a]

[1] Sampling 1, 2, 4 and 7 days after treatment. Letters indicate different groups in the same coloumn according to statistical tests

[2] Letters indicate different groups in the same coloumn according to statistical tests.

Trends of infection and the connection between infection and total cyclic hydroxamic acid content

Tables 5-7 show the powdery mildew infection of wheat plants. Table 5 shows the ratio of infected plants at the first sampling time. The ratio of infected plants did not differ from the untreated control for the effect of biological fungicides in terms of powdery mildew infection. However, the conventional chemical fungicide Sólyom was able to decrease the ratio of infection.

The ratio of the infected area on the examined/sampled leaves was investigated at the second sampling time. Table 6 presents the observed results. Lukullus, Lennox and Ispán had low levels of infection at the second sampling time. In the control plots of Lennox the rate of infection was relatively higher. Compared to this level, applying Sólyom was able to reduce the infection. In accordance with our prior observations hybrid Hystar had the higher rate of infection at the second sampling time. Applying Polyversum or Trifender Pro was ineffective in lowering infection. In this case, too, only Sólyom was able to decrease it.

At the third sampling time infection of the flag leaves was detectable only in the case of the hybrid Hystar. The ratio of infected plants and the rate of the infected area were examined (Table 7).

There were no differences in the ratio of infected plants among the treatments, and between the treatments and the control. The rate of the infected area on the flag leaf, however, was lower in the case of the chemical fungicide, Sólyom, compared to the control, or the biological fungicides. From the ratio of infected plants and the rate of the infected area on the leaves, the ratio of damage

Table 5. Ratio of infected plants at first sampling (%)

Variety/Hybrid Treatments	Repetition	Polyversum	Trifender Pro	Control	Sólyom
Lukullus	1.	10	0	5	5
	2.	5	5	5	0
	3.	10	20	10	5
Lennox	1.	40	70	65	10
	2.	20	5	20	0
	3.	60	50	60	5
Ispán	1.	10	5	5	10
	2.	10	20	20	5
	3.	60	60	20	10
Hystar	1.	70	80	80	70
	2.	80	90	90	20
	3.	90	90	90	30

Table 6. The rate of infected area on the examined/sampled leaves at second sampling time (%)

Variety/Treatments	Repetition	Polyversum	Trifender Pro	Control	Sólyom
Lukullus	1.	1	1	0	0
	2.	1	1	1	1
	3.	1	1	1	1
Lennox	1.	1	1	5	0
	2.	3	3	3	1
	3.	1	1	3	1
Ispán	1.	1	1	1	1
	2.	1	1	1	1
	3.	1	5	5	1
Hystar	1.	25	35	40	3
	2.	25	25	35	3
	3.	40	10	40	1

Table 7. Ratio of infected plants and rate of infected area on flag leaves of hybrid Hystar at the third sampling time (%)

Treatment[1]/ Repetition	P	T	C	S	P	T	C	S
	Ratio of infected plants (%)				Rate of infected area (%)			
1.	20	40	20	40	20	40	40	20
2.	40	40	40	20	40	40	35	30
3.	40	20	20	30	40	40	40	20

[1] P: Polyversum; T: Trifender Pro; C: Control; S: Sólyom

can be calculated using the following equation:

[ratio of infected plants (%) x rate of infected area on leaves (%)]/100.

Thus the rate of damage can be demonstrated in percent (Table 8). Polyversum and Trifender Pro could not lower the ratio of damage, applying Sólyom, however, was effective in this regard.

Table 8. Rate of damage on flag leaves of hybrid Hystar at the third sampling time (%)

Treatment/ Repetition	Polyversum	Trifender Pro	Control	Sólyom
1.	4	16	8	8
2.	16	16	14	6
3.	16	8	8	6

An analysis was carried out to determine the connection between the average infection data and total cyclic hydroxamic acid contents by treatments and/or by the examined varieties/hybrid. Linear associations between the two factors could not be established using scatter plots.

DISCUSSION

Measured cyclic hydroxamic acid contents are in accordance with the data published in earlier publications (Wu et al., 2000; Bonnington et al., 2003). Differences were observed among our examined varieties, which confirms the intraspecific variability in cyclic hydroxamic acid content observed by other authors, too (Copaja et al., 1991; Reberg-Horton et al., 2005; Mogensen et al., 2006;

Makleit et al., 2012). Differences among varieties/hybrid were detectable by all measured data, by treatments and by sampling times as well. Intraspecific variability is especially considerable, given the multiple role of cyclic hydroxamic acids in producer plants. No direct effect of treatments on cyclic hydroxamic acid content could be proved. This result is not surprising given the plants' defending mechanisms. *Pythium oligandrum*, *Trichoderma asperellum* and other species with similar effect, stimulate the plants' defence system, by increasing the synthesis of chemicals like cyclic hydroxamic acids. However, plants will not make any unnecessary effort in the absence of the pathogen, so the production of self-protecting chemicals will not increase. The advantage of using biological fungicides is that the production of self-protecting chemicals in the case of a pathogen infection increases more quickly and reaches a higher level than without a bio-fungicide. In this experiment such effect was not proved. We believe that the effect of infection and disease formation on cyclic hydroxamic acid content can be proved through artificial inoculation. The question is that what the initial level is at the time of infection, and how long the effect lasts. Cyclic hydroxamic acid content decreased with plant ageing when examining the average of the varieties/hybrid's data and or the average of treatments, too. This result confirms results obtained by other authors that cyclic hydroxamic acid content is higher in younger plants and younger plant parts (Thackray et al., 1990; Stochmal et al., 2006). The quantity of continuously produced self-protecting chemicals, like cyclic hydroxamic acids is higher in younger tissues than in older ones. Older parts will function for a shorter time than younger ones. Younger plant parts are more valuable, and energy has to be mobilized for the protection of these parts (hypothesis of optimal protection) (Taiz, 2015). In the case of hybrid Hystar the highest cyclic hydroxamic acid content was measured at the second sampling time. This runs counter to the facts mentioned before. In our opinion, the trend of cyclic hydroxamic acid content changing with ageing was influenced by the considerable infection of this hybrid. Cyclic hydroxamic acids proved to be stress metabolites (Niemeyer, 1988; 2009). Not only powdery mildew infection, but various biotic and abiotic stressors can influence the level of these chemicals. The higher total cyclic hydroxamic acid content of variety Ispán can be explained by this fact because this variety was attacked more by another biotic stressor, *Oulema melanopus* (personal observation, not confirmed by collected data). Powdery mildew infection decreased constantly in the growing season. Infection was detected at the first sampling time, but the biological fungicides were unable to reduce it. However, the chemical fungicide Sólyom was effective. At the second and third sampling times only the hybrid, Hystar had a considerable rate of powdery mildew infection. Only Sólyom was effective at these sampling times too. Taking into consideration the date of treatments and the data of infection at different sampling times, the efficacy (the duration of efficacy) of the chemical fungicide lasts five weeks (from 11th of April to 16th of May in this case). The reason why the powdery mildew infection decreased in the experiment in all treatments was that the weather conditions were unfavourable for further infection cycles, and the examined varieties were more or less tolerant to the infection. According to the few publications in the topic of connection between cyclic hydroxamic acid content and rate of powdery mildew infection (Brandes and Heitefuss, 1971; Zheng et al., 2005), the varieties with higher cyclic hydroxamic acid content had lower rates of infection. Our experiment demonstrated adverse results. Varieties/hybrid with higher cyclic hydroxamic acid content had higher rates of infection. In our opinion, the infection as a biotic stressor induced the synthesis of cyclic hydroxamic acids and increased their quantity. Cyclic hydroxamic acid content was not measured prior to the infection, as in the field the time and date of the infection cannot be predicted. There was no linear correlation between the rate of infection and cyclic hydroxamic acid content. Some conclusions can, however, be drawn from the differences in cyclic hydroxamic acid content and in the rate of powdery mildew infection of varieties/hybrid. Variety Ispán and hybrid Hystar, with higher rates of infection, had higher cyclic hydroxamic acid content. On the one hand, plants continuously produce cyclic hydroxamic acids (constitutive character) and on the other, these chemicals have an inductive character, which means that their production is increased by pathogens, pests and abiotic stressors. One explanation for the obtained results can be that, in the case of infection, plants try to decrease the rate of damage caused by the pathogens through the effects of a higher cyclic hydroxamic acid content. In contrast, the lower rates of infection shown by varieties Lukullus and Lennox must be related to the complex nature of resistance. What can be the reason for the lower rates of infection shown by varieties Lukullus and Lennox? Resistance depends not only on cyclic hydroxamic acid content, but on morphological, and other biochemical characteristics as well. Other facts further complicate the role of cyclic hydroxamic acids in the infection and disease formation process. The diverse connection of the host plant and the pathogen influences the amount of cyclic hydroxamic acids and their decomposition products at the interface between host and pathogen. In some cases this elevated level is not connected with the cyclic hydroxamic acid contents in other parts of the plants (Weibull and Niemeyer, 1995). In addition, various pathogens have different abilities to decompose cyclic hydroxamic acids (Friebe et al., 1998).

CONCLUSIONS

The conclusion drawn from these results is that the role of cyclic hydroxamic acids in the infection and disease formation could be clarified through artificial inoculation and continuous monitoring of these chemicals before and after the inoculation, throughout the disease formation process. Comparing the applied fungicides' effectivity against the examined pathogen it can be stated that only the conventional fungicide proved to be efficient in case of every examined variety/hybrid. The application of biological fungicides were ineffective in this experiment.

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